Antecedents and Neonatal Consequences of Low Apgar Scores in Preterm Newborns

A Population Study

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Background: To examine the antenatal and early neonatal correlates of low Apgar scores (<3 and <6 at 1 and 5 minutes) in preterm newborns (23-34 weeks' gestation).

Objective: The use of Apgar scoring for premature newborns remains widespread, despite controversy regarding its reliability as a measure of morbidity and mortality in the neonatal period.

Design: A cohort of 852 preterm newborns born during a 34-month period between 1984 and 1987 was studied. Newborns were stratified into 2 groups by gestational age (23-28 weeks and 29-34 weeks), and data were analyzed, controlling for gestational age in single weeks.

Setting: Two academic and 1 community hospital, which together accounted for 83% of all preterm births in a tri-county area of central New Jersey during the study period.

Patients: All premature newborns (birth weight <2000 g and gestational age <35 weeks) born in the participating hospitals during the study period were evaluated.

Main Outcome Measures: Antecedents included maternal illness during pregnancy, maternal complications of labor and delivery, and fetal heart rate abnormalities during labor and delivery. Consequences included delivery room resuscitation, abnormal physiological findings, diagnoses, and therapeutic interventions in the first 6 to 8 hours of life.

Results: Premature newborns with low Apgar scores received more cardiopulmonary resuscitation in the delivery room and in the first 6 to 8 hours of neonatal intensive care. Mortality was significantly increased among newborns with low Apgar scores (54% vs 26% in the 23- to 28-week stratum, 30% vs 6% in the 29- to 34-week stratum). Newborns with low Apgar scores in the 29- to 34-week stratum more often required intubation, positive pressure ventilation, and umbilical vessel catheterization. Newborns with low Apgar scores had higher rates of bradycardia, pneumothoraces, acidosis, and increased oxygen requirement during the first 6 to 8 hours of life. Maternal illness, complications of labor and delivery, and fetal heart rate decelerations did not correlate with subsequent Apgar scores of newborns. The presence of severe bradycardia (<90/min) and fetal heart rate accelerations correlated with low Apgar scores in the 29- to 34-week group.

Conclusion: Low Apgar scores are associated with increased neonatal morbidity and mortality in preterm newborns. Antenatal maternal history and pregnancy complications are not clearly associated with low Apgar scores. Therefore, the Apgar score is a useful tool in assessing neonatal short-term prognosis and the need for intensive care among preterm newborns.

PATIENTS AND METHODS

STUDY POPULATION

Between September 1, 1984, and June 30, 1987, 1105 newborns weighing 500 to 2000 g at birth in 3 hospitals in central New Jersey (St. Peter’s University Hospital, New Brunswick; Monmouth County Medical Center, Long Branch; and Jersey Shore Medical Center, Neptune) were enrolled in a prospectively studied cohort. Enrollment consisted of 100% of qualified newborns in these centers and approximately 83% of all births within this weight range in the tricounty region (Middlesex, Monmouth, and Ocean counties) during this period. For purposes of analysis, newborns in the study born at 34 weeks’ or less gestation were stratified into 2 groups based on gestational age: 23 to 28 weeks’ gestation (n = 261) and 29 to 34 weeks’ gestation (n = 591). Newborns in this cohort with birth weights less than 2000 g and gestational age greater than 34 weeks were excluded from analysis because this group contains a large proportion of growth-retarded, nearly mature newborns. We defined the low Apgar group as newborns with Apgar scores of less than 3 and less than 6 at 1 and 5 minutes, respectively.

CLINICAL VARIABLES

Maternal and newborn data were obtained by review of the prospectively designed comprehensive database of all infants enrolled in the Central New Jersey Neonatal Brain Hemorrhage Study. The information for all participating patients was compiled daily from medical charts at each of the 3 study sites by nurses who were trained exclusively for the project. Validation of data collection uniformity and accuracy at each site and between sites was performed periodically.

A total of 1105 newborns were enrolled between August 1984 and June 1987, with a birth weight of 1393 ± 406 g and a gestational age of 31 ± 4 weeks. There were 261 newborns in the 23- to 28-week gestation stratum (Table 1). In this stratum, the low Apgar group (n = 54) weighed 796 ± 207 g at birth and had a gestational age of 25.7 ± 1.6 weeks; values were significantly different from the normal Apgar group (n = 207) in this stratum (1007 ± 289 g, 26.5 ± 1.4 weeks). The low and normal Apgar groups were comparable with regard to sex and race. A significantly higher proportion of deaths occurred in the low Apgar group.

A total of 591 newborns were enrolled in the 29- to 34-week stratum. The low (n = 30) and normal Apgar (n = 561) groups were comparable with respect to gestational age (31.1 ± 1.6 and 31.4 ± 1.6 weeks, respectively), race, and sex but differed with respect to birth weight (1418 ± 324 g and 1536 ± 296 g, respectively) and proportion of deaths (Table 1).

RELATION BETWEEN APGAR SCORES AND POSTNATAL MORBIDITY

Newborns in the low Apgar groups were more unstable in the delivery room, requiring more aggressive resuscitation (Table 2). In both gestational age strata, newborns with low Apgar scores had significantly greater requirements for cardiopulmonary resuscitation with cardiac...
massage and for umbilical vein cannulation. Significantly more newborns with low Apgar scores were treated with sodium bicarbonate and epinephrine. Although more than 80% of all newborns born at 34 weeks’ or less gestation received oxygen in the delivery room, the need for positive pressure bag and mask ventilation was significantly greater in the low Apgar group in the 29- to 34-week stratum (OR = 8.7). However, in the 23- to 28-week stratum, the prevalence of bag and mask ventilation was high and did not correlate with the low or normal Apgar score group. Likewise, intubation and mechanical ventilation were significantly increased among newborns with low Apgar scores in the 29- to 34-week stratum (OR = 37.6), but these interventions were prevalent in the 23- to 28-week group, and did not correlate with Apgar score group in that stratum.

Clinical findings and diagnoses observed in the immediate newborn period (observation interval, 6.5 ± 0.2 hours) are presented in Table 3. In the 29- to 34-week group, newborns with low Apgar scores were more likely to display hypothermia (temperature <36°C), cyanosis, hypotonia, and heart murmurs than newborns with normal Apgar scores. These findings were not significantly correlated with Apgar scores in the 23- to 28-week group. However, in both strata, the incidences of bradycardia (<120/min), pallor, and pneumothoraces were correlated with Apgar group, indicating that important clinical findings in the immediate newborn period were predicted by Apgar scores. Defining hypotension according to the ranges previously reported from this data set for systolic and diastolic blood pressures in the subset of healthy preterm newborns,12 we found that the incidence of hypotension was not related to Apgar score group in either gestational age category.

Neonatal laboratory data during the observation interval (6.5 ± 0.2 hours) are shown in Table 4. In both gestational age strata, the newborns with low Apgar scores had significantly lower levels of hemoglobin. Serum pH was lower in newborns with low Apgar scores in both strata and was associated with carbon dioxide retention. Newborns with low Apgar scores in both gestational age groups required higher fraction of inspired oxygen. Interestingly, these newborns demonstrated higher serum glucose levels in this interval than those with normal scores (statistically significant in the 29- to 34-week stratum).

Premature newborns in the low Apgar group remained more unstable during the period of observation (Table 5). Significantly more newborns with low Apgar scores in both strata required sodium bicarbonate and

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**Table 1. Description of the Patient Population**

<table>
<thead>
<tr>
<th>Variable</th>
<th>23-28 Weeks’ Gestation</th>
<th>29-34 Weeks’ Gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>Birth weight, mean ± SD, g</td>
<td>796 ± 207</td>
<td>1007 ± 289*</td>
</tr>
<tr>
<td>Gestational age, mean ± SD, wk</td>
<td>26.7 ± 1.6</td>
<td>26.5 ± 1.4*</td>
</tr>
<tr>
<td>Male:female, %</td>
<td>50:50</td>
<td>52:48</td>
</tr>
<tr>
<td>White:black, %</td>
<td>63:37</td>
<td>59:41</td>
</tr>
<tr>
<td>Apgar score at 1 min, mean ± SD</td>
<td>1.2 ± 0.7</td>
<td>5.0 ± 2.1*</td>
</tr>
<tr>
<td>Apgar score at 5 min, mean ± SD</td>
<td>3.2 ± 1.5</td>
<td>7.1 ± 1.6*</td>
</tr>
<tr>
<td>Deaths, No. (%)</td>
<td>29 (54)</td>
<td>54 (26)*</td>
</tr>
</tbody>
</table>

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**Table 2. Delivery Room Procedures**

<table>
<thead>
<tr>
<th>Variable</th>
<th>23-28 Weeks’ Gestation</th>
<th>29-34 Weeks’ Gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>Oxygen</td>
<td>44 (82)</td>
<td>174 (84)</td>
</tr>
<tr>
<td>Bag and mask PPV</td>
<td>39 (72)</td>
<td>141 (68)</td>
</tr>
<tr>
<td>Intubation</td>
<td>46 (85)</td>
<td>145 (70)</td>
</tr>
<tr>
<td>CPR</td>
<td>8 (15)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>UAC</td>
<td>9 (17)</td>
<td>14 (7)</td>
</tr>
<tr>
<td>UVC</td>
<td>8 (15)</td>
<td>5 (2)</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>11 (20)</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>7 (13)</td>
<td>4 (2)</td>
</tr>
</tbody>
</table>

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epinephrine, and cardiopulmonary resuscitation with chest compressions. In the 23- to 28-week stratum, newborns with low Apgar scores also required calcium (OR = 4.9) more frequently. In the 29- to 34-week stratum, newborns with low scores were more likely than those with normal scores to require mechanical ventilation (OR = 28.9), umbilical artery catheterization (OR = 3.5), and dopamine hydrochloride (OR = 36.4).

**RELATION BETWEEN COMPLICATIONS OF PREGNANCY AND DELIVERY AND APGAR SCORES**

We next examined prenatal and perinatal factors that might be associated with low Apgar scores in this population. For maternal variables, the statistical significance of differences between groups was assessed, controlling for gestational age of the newborns in single weeks within each gestational age stratum (analysis of variance and covariance controlling for gestational age for continuous variables, and ORs adjusted for gestational age by logistic regression for categorical variables). In both gestational age strata, the maternal populations of newborns with low and normal Apgar scores did not differ in age, schooling, or the proportions of primigravidas. The low and normal Apgar score populations within each stratum were not different with respect to clinical measures during labor and delivery. Of note, there were no differences between the 2 groups with respect to vaginal bleeding or preeclampsia. The use of narcotics or magnesium during labor was not associated with low Apgar scores, although tranquilizer use was associated with low scores in the 29- to 34-week group (OR = 2.6). Use of oxytocin was not different in the low and normal Apgar groups. Maternal blood pressures or temperatures during labor did not correlate with Apgar scores. Interestingly, in the context of contemporary obstetric care, documented positive cultures of the urine or amniotic fluid could not be correlated with subsequent Apgar scores in these groups of premature newborns. Maternal hemato-

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**Table 3. Abnormal Clinical Findings in the First 6 to 8 Hours of Life**

<table>
<thead>
<tr>
<th>Variable</th>
<th>23-28 Weeks’ Gestation</th>
<th>29-34 Weeks’ Gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Apgar, No. (%)</td>
<td>Normal Apgar, No. (%)</td>
</tr>
<tr>
<td>No. of patients</td>
<td>54</td>
<td>207</td>
</tr>
<tr>
<td>Bradycardia (heart rate &lt;120/min)</td>
<td>18 (33)</td>
<td>28 (14)</td>
</tr>
<tr>
<td>Systolic hypotension (systolic blood pressure &lt;47 mm Hg)</td>
<td>46 (85)</td>
<td>175 (85)</td>
</tr>
<tr>
<td>Diastolic hypotension (diastolic blood pressure &lt;28 mm Hg)</td>
<td>40 (74)</td>
<td>156 (75)</td>
</tr>
<tr>
<td>Hypothermia (&lt;36°C)</td>
<td>44 (81)</td>
<td>138 (67)</td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>46 (85)</td>
<td>171 (83)</td>
</tr>
<tr>
<td>Apnea</td>
<td>7 (15)</td>
<td>21 (10)</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>27 (50)</td>
<td>85 (41)</td>
</tr>
<tr>
<td>Pallor</td>
<td>4 (7)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>Hypoesthesia</td>
<td>10 (19)</td>
<td>28 (14)</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>5 (9)</td>
<td>7 (3)</td>
</tr>
<tr>
<td>Heart murmurs</td>
<td>2 (4)</td>
<td>8 (4)</td>
</tr>
</tbody>
</table>

*Odds ratio (OR) (95% confidence interval [CI]) after adjusting for gestational age. Ellipses indicate data not applicable.

**Table 4. Laboratory Data in the First 6 to 8 Hours of Life**

<table>
<thead>
<tr>
<th>Variable</th>
<th>23-28 Weeks’ Gestation</th>
<th>29-34 Weeks’ Gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>54</td>
<td>207</td>
</tr>
<tr>
<td>Hemoglobin, g/L</td>
<td>134 ± 31</td>
<td>150 ± 22†</td>
</tr>
<tr>
<td>WBC, ×10^9/L</td>
<td>18.5 ± 13.7</td>
<td>14.6 ± 10.8</td>
</tr>
<tr>
<td>Platelets, ×10^9/L</td>
<td>224 ± 77</td>
<td>241 ± 81</td>
</tr>
<tr>
<td>Sodium, mmol/L</td>
<td>140 ± 6.8</td>
<td>136 ± 5.4†</td>
</tr>
<tr>
<td>Potassium, mmol/L</td>
<td>5.0 ± 0.7</td>
<td>4.9 ± 1.1</td>
</tr>
<tr>
<td>Carbon dioxide, mmol/L</td>
<td>15.2 ± 5.3</td>
<td>18.8 ± 6.7</td>
</tr>
<tr>
<td>Glucose, mmol/L (mg/dL)</td>
<td>4.6 ± 4.5 (82 ± 81)</td>
<td>3.7 ± 2.7 (67 ± 48)†</td>
</tr>
<tr>
<td>Calcium, mmol/L (mg/dL)</td>
<td>2.05 ± 0.4 (82 ± 1.6)</td>
<td>2.18 ± 0.22 (87 ± 0.9)</td>
</tr>
<tr>
<td>FiO₂, %</td>
<td>84 ± 21</td>
<td>64 ± 27†</td>
</tr>
<tr>
<td>pH</td>
<td>7.21 ± 0.21</td>
<td>7.31 ± 0.13†</td>
</tr>
<tr>
<td>Paco₂, mm Hg</td>
<td>50 ± 27</td>
<td>44 ± 16†</td>
</tr>
<tr>
<td>Paco₃, mm Hg</td>
<td>125 ± 111</td>
<td>115 ± 97</td>
</tr>
</tbody>
</table>

*Data are expressed as mean ± SD. WBC indicates white blood cell count; FiO₂, fraction of inspired oxygen.

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logic variables (hemoglobin, leukocyte count) and serum calcium and magnesium levels were also not predictive of the Apgar scores of newborns.

Antenatal fetal monitoring was used for most newborns in this cohort. In the 23- to 28-week group, 44 of 54 newborns with low Apgar scores (1 internal monitor and 43 external) and 183 of 207 with normal scores were monitored (6 internal, 169 external, and 8 both). Among newborns in the 29- to 34-week gestational age group, 21 of 30 with low Apgar scores (20 external and 1 both) and 491 of 561 with normal scores were monitored (27 internal, 423 external, 39 both, and 2 unspecified). Fetal heart rate decelerations during labor were not correlated with low scores. Among 29- to 34-week newborns, the sensitivity and positive predictive value of late decelerations in predicting low Apgar scores were 4% and 5%, respectively. Similarly, the positive predictive value of late decelerations in predicting low scores in the 23- to 28-week newborns was 11%. Although the occurrence of severe bradycardia (<90/min) was significantly more likely with low scores in the 29- to 34-week group (29% vs 10%, OR = 2.8), the sensitivity and positive predictive value of severe bradycardia in predicting low scores in these newborns were 11% and 29%, respectively. However, the absence of severe bradycardia was more predictive of normal Apgar assignment, demonstrating negative predictive values of 91% and 90% in the 23- to 28-week and 29- to 34-week newborns, respectively. The negative predictive values of late fetal heart rate decelerations in predicting low Apgar scores (94% in the 23- to 28-week newborns, 95% in the 29- to 34-week newborns) also greatly exceeded the positive predictive values.

### Table 5. Therapeutic Interventions in the First 6 to 8 Hours of Life

<table>
<thead>
<tr>
<th>Variable</th>
<th>23-28 Weeks’ Gestation</th>
<th>29-34 Weeks’ Gestation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Apgar, No. (%)</td>
<td>Normal Apgar, No. (%)</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>207</td>
</tr>
<tr>
<td>Calcium</td>
<td>4 (7)</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Glucose</td>
<td>2 (4)</td>
<td>7 (3)</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>24 (44)</td>
<td>25 (12)</td>
</tr>
<tr>
<td>Dopamine hydrochloride</td>
<td>9 (17)</td>
<td>10 (5)</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>10 (19)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>Packed red blood cells</td>
<td>8 (15)</td>
<td>15 (7)</td>
</tr>
<tr>
<td>Ventilatory support</td>
<td>46 (85)</td>
<td>164 (79)</td>
</tr>
<tr>
<td>Cardiopulmonary resuscitation</td>
<td>11 (20)</td>
<td>9 (4)</td>
</tr>
<tr>
<td>Umbilical arterial catheter</td>
<td>46 (85)</td>
<td>172 (83)</td>
</tr>
<tr>
<td>Umbilical venous catheter</td>
<td>19 (33)</td>
<td>90 (44)</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>561</td>
</tr>
<tr>
<td>Calcium</td>
<td>1 (3)</td>
<td>7 (1)</td>
</tr>
<tr>
<td>Glucose</td>
<td>2 (7)</td>
<td>9 (2)</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>11 (37)</td>
<td>23 (4)</td>
</tr>
<tr>
<td>Dopamine hydrochloride</td>
<td>5 (17)</td>
<td>2 (0)</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>3 (10)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Packed red blood cells</td>
<td>2 (7)</td>
<td>10 (2)</td>
</tr>
<tr>
<td>Ventilatory support</td>
<td>28 (93)</td>
<td>206 (37)</td>
</tr>
<tr>
<td>Cardiopulmonary resuscitation</td>
<td>5 (17)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>Umbilical arterial catheter</td>
<td>23 (77)</td>
<td>272 (48)</td>
</tr>
<tr>
<td>Umbilical venous catheter</td>
<td>10 (33)</td>
<td>38 (7)</td>
</tr>
</tbody>
</table>

* Odds ratio (OR) (95% confidence interval [CI]) adjusted for gestational age. Ellipses indicate data not applicable. †P<.05 in the same gestation group.

Apgar scores in full-term newborns often reflect perinatal compromise, and have been correlated with short-term prognosis and long-term outcome.13-15 The utility and popularity of these scores are based primarily on their efficacy as predictors of neonatal morbidity and mortality in full-term neonates. Apgar scoring is generally applied to premature newborns using the same criteria as for full-term newborns. However, several criteria used in determining Apgar score (muscle tone, reflex irritability, and respiratory effort) are developmentally determined. Therefore, it has been suggested that the Apgar scores in premature newborns may reflect neurodevelopmental maturity more than fetal compromise. In a large, unselected population of premature newborns, we examined the implications of Apgar scores in the immediate newborn period. Our data indicate that premature newborns with low Apgar scores tend to be less mature and of lower birth weight than control newborns; this observation agrees with previous investigations.2,16

Our data support the utility of Apgar scores in predicting morbidity and mortality in the immediate newborn period. Low scores were correlated with higher incidences of neonatal interventions and complications. Newborns with low scores required significantly more positive pressure ventilation, intubation, cardiopulmonary resuscitation, umbilical catheterization, and intravenous medications. In full-term newborns, Apgar scores sometimes reflect the consequences of perinatal asphyxiating events. Low Apgar scores in premature newborns likewise indicate a higher incidence of acidosis and other sequelae of perinatal insult, such as hypotonia in 29- to 34-week newborns, and increased bradycardia and pallor in both gestational age groups.

Mortality was significantly higher in the low than the normal Apgar groups. However, the relatively high mortality in the normal group suggests that, unlike in full-term newborns, high Apgar scores do not necessarily predict a good long-term outcome. By 1 and 5 minutes, newborns may achieve normal Apgar scores as a result of medical interventions. Serum glucose levels were higher in newborns with low Apgar scores, likely reflecting the greater use of intravenous fluid therapy in these groups. Nevertheless, newborns in this cohort remain subject to high mortality risks associated with other independent sequelae of prematurity. Our data indicate that Apgar scores in the premature population correlate with measures of short-term outcome and with mortality, despite concerns that such scoring might be invalidated by...
the effects of neonatal resuscitation during the first minutes of life.

INTERPRETATION OF Apgar scores in premature newborns is controversial. Some investigators1,3,16 reported that Apgar scores in newborns of 24 to 36 weeks gestational age did not correlate with umbilical cord pH as an indicator of perinatal asphyxia. Bowes et al8 reported that fetal heart rate monitoring—but not Apgar score—was predictive of umbilical artery pH. Others16,16 reported low Apgar scores as correlating primarily with gestational age alone, in the absence of other indicators of fetal distress. Conversely, Amon et al7 reported that the 5-minute Apgar score correlated well with survival in newborns with birth weights less than 1000 g. The 1- and 5-minute Apgar scores, combined with gestational age or birth weight, are more potent predictors of neonatal mortality than any single factor.17,18 Therefore, although there is little evidence to support the use of Apgar scoring in the diagnosis of birth asphyxia in premature newborns, they can be a useful measure of an infant’s status at birth, which correlates with survival. The 1- and 5-minute Apgar scores have also been shown to be predictive of multisystem morbidity in the neonatal period in newborns of gestational age less than 37 weeks.8,9 Furthermore, Apgar scores have been correlated closely with the incidence and severity of periventricular and intraventricular hemorrhages in premature newborns.19

Newer, more inclusive scoring systems have been devised to predict mortality in premature newborns. The CRIB score, developed by the International Neonatal Network, is based on birth weight, gestational age, the presence or absence of congenital anomalies, and physiologic variables during the first 12 hours of life (maximum and minimum appropriate fraction of inspired oxygen and maximum base deficit).8,9 Although this measure has been shown to be more effective than birth weight alone as a predictor of survival to discharge, it is subject to imprecision based on differences in obstetric and neonatal management during the first 12 hours of life. Moreover, 1- and 5-minute Apgar scores (as well as gestational age) have been shown to be strongly associated with illness severity, as measured by the CRIB score.10 This underscores the value of Apgar scoring as a predictive measure that is available within minutes of birth. The 5-minute Apgar score was recently incorporated into a scoring system by Maier et al.20 which uses factors that are readily available on admission, and which is highly predictive of neonatal mortality.

The refinement of Apgar scores and other clinical measures in the immediate postnatal period to predict morbidity, mortality, and the need for neonatal intensive care assumes added significance because of our finding that maternal antenatal variables are not correlated with subsequent Apgar scores of newborns. We found that maternal conditions during pregnancy such as vaginal bleeding and preeclampsia; use of medications during labor, including oxytocin, magnesium, and narcotics; maternal vital signs, including temperature; and hematologic parameters did not correlate with lower Apgar scores. Interestingly, documented urinary tract or amniotic fluid infections were not associated with lower Apgar scores in these patients. Clearly, management patterns, such as greater use of antibiotics in the low Apgar group, affect outcome measures. Previous reports of neonatal outcomes relative to antenatal complications have been contradictory. Ferguson et al21 reported that adverse outcome for newborns delivered of mothers with clinical amniotic fluid infection was related primarily to prematurity alone. Another group22 reported that the occurrence of antepartum hemorrhage, pregnancy-induced hypertension, and amnionitis had no influence on outcome in very low-birth-weight newborns. Conversely, in a study of 123 women with intra-amniotic infection and 6769 women without infection, Maberry and coworkers23 noted that significantly more newborns in the infected group (20% vs 5%) had a low 1-minute Apgar score of 6 or less, but none had a score of 3 or less. Given this ambiguity in the context of modern obstetric management, maternal medical history is of little use in predicting Apgar scores in low-birth-weight newborns.

Antenatal fetal heart rate monitoring provides information that is often used to determine clinical management. Indeed, we found a correlation between severe antenatal bradycardia and subsequent low Apgar scores in both gestational age groups, significantly so in the 29- to 34-week newborns. However, several prior investigations24-26 have demonstrated that fetal heart rate monitoring is an imprecise measure of fetal acidemia. Apgar score, and neonatal mortality. In a prospective study of 6825 labors, Curzen et al27 found that the sensitivity of an abnormal tracing for newborns with an Apgar score of less than 7 was 23.2% and the positive predictive value was 27.4%. The specificity of the tracing was 93.4% for newborns with an Apgar score of 7 or more. Similarly, we found that late fetal heart rate decelerations and severe fetal bradycardia demonstrated far greater negative than positive predictive values with regard to infants’ subsequent Apgar scores. There was no statistically significant correlation between late fetal decelerations and Apgar scores in these preterm newborns, and the correlation between severe fetal bradycardia (<90/min) and Apgar scores was significant only in the 29- to 34-week group. The relatively high incidence of false-positive predictions is explained on the grounds that abnormalities in the cardiotocograph tracing may be more sensitive indicators of subclinical hypoxia than the Apgar score, or that these measures are unrelated to hypoxia. False-negative predictions are likely due to adverse factors other than hypoxia such as fetal trauma or compression of the head. These findings indicate that, although normal fetal heart rate tracings are suggestive of fetal health, cardiotocography should not be relied on as the sole method of assessing fetal distress. Antenatal indicators of neonatal depression have much higher negative predictive values than positive predictive values and so are more effective at predicting the absence of rather than the presence of neonatal complications. The weak relation between antenatal events and neonatal outcome may be partly related to successful management, which alters the natural history of antecedent events.

In summary, despite concerns about the physiologic applicability of Apgar scoring as a prognostic in-
indicator in premature newborns, our data indicate that low Apgar scores are indeed associated with increased neonatal morbidity, mortality, and the need for intensive care intervention. Since antenatal maternal history and pregnancy complications are not clearly associated with adverse neonatal outcomes, the Apgar score is currently the most widely available measure to assess neonatal short-term prognosis. It is likely that the utility of Apgar scores will be enhanced in conjunction with other measures of perinatal stress (eg, umbilical artery pH, CRIB score) or as a component of more extensive composite scoring. The challenge remains to find better prenatal and perinatal predictors of Apgar scores in these newborns so that interventions can be best matched to their needs.

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